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Factors of Influence for Implementing Curriculum Reform: An analysis based on a systematic literature review

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To get an overview of the characteristics of the studies in mathematics education research that explicitly purport to concern implementation, we have conducted a systematic literature review. We report on a subset of twelve papers investigating and discussing factors of influence that are decisive for implementing curriculum reforms. Results show that curriculum change does not occur independently of a change in teachers' concerns, beliefs, views, and images about the nature of mathematics teaching and learning. Also, the school's support level and the innovations' adaption to context are decisive for the implementation outcome. Design for evaluation of curricular reforms may benefit from explicating the supposed main factors of influence and design methods of evaluating their mechanisms.

Keywords: Mathematics curriculum reform, implementation research, factors of influence.

Introduction

Implementation research, by our working definition, is the systematic inquiry of innovations enacted in controlled settings or in ordinary practice, the factors that influence innovation enactment, and relationships between innovations, influential factors, and outcomes. (Century & Cassata, p. 181)

Implementation research (IR) in mathematics education research (MER) has gained momentum during the past few years. Some indications of this fact are that since 2017, a thematic working group (TWG 23) at CERME has been dedicated to the topic, and a new specialized journal—*Implementation and Replication Studies in Mathematics Education* (IRME)—published its first two issues in 2021. Also, in 2021, a special issue of ZDM was dedicated to the topic of implementation research in MER (Koichu et al., 2021).

Typical issues dealt with in relation to IR in MER concern the use of theoretical constructs from fields such as health science, economics, etc., versus constructs developed specifically for MER; what we should take *implementability* to mean in relation to IR in MER; to what extent IR should mainly address large scale studies; etc. (Jankvist et al., 2021). When discussing such issues, a natural starting point is to get an overview of the numerosity and type of studies in the MER literature specifically addressing implementation. We have taken on this task by conducting a systematic literature review.

Such a review involved a few delicate considerations on our behalf, not least since a large portion of the research studies in MER may be considered studies addressing some kind of implementation. We settled on two inclusion criteria to avoid a too large number of papers. Firstly, we limited the review

to include papers that clearly stated to be dealing with implementation. Secondly, we limited the review to only considering studies published in the top twenty quality-ranked MER journals, following the recent journal categorization by Williams and Leatham (2017). In this paper, we focus on a smaller subset of the identified studies, consisting of twelve papers that explicitly address factors affecting the enactment of curriculum reform. The research question is: *What factors of influence are decisive for the outcome of the implementation of a curriculum reform?*

Review methodology

We conducted the literature review using as a starting point the ERIC database. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al., 2009) were followed to structure our review study. We searched for manuscripts with *implement** in the title and/or abstract, journal by journal of our top 20 samples (Williams & Leatham, 2017). To ensure that no article had been overlooked, we repeated the search *implement** in the title and/or abstract on each of the 20 journals' websites. We found 1,093 peer-reviewed articles fitting the inclusion criteria. The selection of articles followed the four main steps of PRISMA: (1) identification, (2) screening, (3) eligibility, and (4) inclusion (Moher et al., 2009). The literature search was carried out on February 4-5, 2021. We used the software Covidence to manage our systematic review.

Two reviewers screened each paper. The screening was made in two steps. First, we screened the title and abstract. In cases where we were hesitant, e.g., because the abstract did not provide sufficient information, we forward the paper to full-text screening. A total of 138 papers were forwarded to full-text screening, where papers were included if they fit under Century and Cassata's (2016) definition of IR (quoted above). *Innovation* in the IR definition refers to the practical implementation of ideas resulting from research on improving education (Century & Cassata, 2016).

Of the 138 papers, 95 remained after the full-text screening. To obtain smaller and more manageable units, these were categorized as: Instructional sequences on mathematical concepts and/or competencies (19), Curriculum materials (21), Professional development (PD) projects (25), and Curriculum reform (30). There are no clear cuts between the categories. An instructional sequence may stem from a new curriculum material implemented through a PD project due to curriculum reform. The category foregrounded in each of the 95 papers was decisive for how the categorization was done.

The data extraction from the papers included general information on the author(s), title, purpose statement(s), country where the study was conducted, research question(s), methods, target group, and results. The specific information about the implementations included what kind of innovation from mathematics education the study concerned, specific or general goals of short term or long term, phase of the implementation studied, stakeholders responsible for the implementation, and identified factors of influence for the implementation outcomes. This paper focuses on the subset of twelve papers explicitly addressing factors of influence for enacting curriculum reform.

IR theoretical constructs applied

One reason to conduct implementation research is to discover factors of influence in the enactment (of the innovation) that are crucial for whether the innovation works (Century & Cassata, 2016). *Factors of influence* are defined as characteristics of four spheres: the innovation, the user, the organization, and the external environment. What constitutes these characteristics varies depending on the context in which the implementation is studied (e.g., hospital, football club, manufacturing industry, etc.). Here, we are interested in the school and why we identify the four categories in the school context.

The innovation: In line with Century and Cassata (2016), we define innovations as “the object or focus for change” (p. 170). In this paper, we are only considering innovations carried out by curriculum reform that stem from ME research. Factors of influence inherent to the innovation are applicability and adaptability to the users and the practice where it will be implemented.

The user: The user in curriculum reform is the teachers since teachers are key players in all educational reforms in the role of agents of change in schools and classrooms. Factors of influence for implementation projects are teachers’ level of understanding of the innovation and their mathematical and pedagogical expertise. Also, prior experience, organizational skills, classroom management style, and affective traits such as beliefs, values, attitudes, motivation, self-efficacy, and willingness to try new things are FoI for innovation implementation (Century & Cassata, 2016).

The organization: The organizational factors of influence that regulate implementation projects originate from a system of decisions made by stakeholders in the school. Examples of organizational factors of influence are decisions on class size, the allocation of resources, the physical space, scheduling, and the organizational structure of teachers’ work. Also, the administration, management, and policy-making processes related to the innovation in play are characteristics of organizational factors of influence.

The external environment: Affordances and constraints formed outside the organization (over which the organizations’ stakeholders have no influence) that impact innovation enactment are considered factors of influence from the external environment. It is typical for factors of influence that belong to the external environment that stakeholders in the school do not have the power to influence decision-making. Economic conditions, infrastructure, and shifting political focus are examples of external influences with the power to influence innovation. It can be tangible things, such as the connections being so bad that it is difficult for PD supervisors to reach out to the schools and policy decisions about the schools’ budgets after a change of political power.

Below, we identify which factors of influence are stated as reasons for the success or failure of implementing curriculum reform in the reviewed articles.

Results

Six countries are represented in the sample of the twelve identified papers, explicitly investigating factors of influence for enacting curriculum reform in line with the intended reform. We report on the identified factors of influence country by country, starting with the earliest study, from Brazil in 1991, and ending with the latest, from Bhutan in 2018. After that, we categorize the factors of influence as

characteristics of *the innovation, the user, the organization, and the external environment*. We also categorize the studies as *a priori* or *a posteriori* to distinguish whether the study enters with a prior idea of the existence of a specific factor of influence under investigation (*a priori*) or if the identified factors of influence stem from the empirical investigation (*a posteriori*).

In Brazil, an *a posteriori* analysis of the mathematics curricular reform movement in the 1960s concluded that the implementation was not a success (D'Ambrosio, 1991). The reform was built on a transfer of knowledge from a developed to a developing country, which created practical problems such as incorrect translations of curriculum documents. Also, mathematics that the teachers themselves had not studied, such as set theory, was introduced by the curriculum reform. In addition, there was a lack of teacher preparation and textbooks supporting reformed mathematics. Yet, the teachers' beliefs were the most important factor of influence for the failure of implementing a reformed curriculum in Brazil. The reformed ideas about how teaching should be carried out did not align with the teachers' own beliefs about the practice of teaching and learning. D'Ambrosio concludes:

Curriculum change does not occur independently of a change in teachers' beliefs about the nature of mathematics, the nature of mathematics learning and the nature of mathematics teaching." (D'Ambrosio, 1991, p. 84)

In Cyprus, a reformed mathematics curriculum was gradually implemented from 1995 in grade 1, the next year in grade 2, and so on until 2000, when grades 1 through 6 were covered. In our sample, two *a priori* studies show that teachers' concerns and beliefs are influential factors in enacting reformed mathematics (Charalambous & Philippou, 2010; Christou et al., 2004). The reform was implemented without substantial professional development. Instead, a mandated mathematics textbook and a teacher guide were intended to carry the reform ideas to the classroom. Data from a questionnaire with 655 teachers showed that elementary teachers generally felt capable of meeting the demands of reformed mathematics but were concerned about planning the daily work with the new textbook and large student groups (Christou et al., 2004). Charalambous and Philippou (2010) report that after five years of reform, the 155 elementary teachers in their study argued that they were not sufficiently acquainted with the reform. In additional interview data from 53 teachers, the opinion that the teacher manual did not convey the underlying philosophy of the reform was put forward. Findings also showed that teachers who were happy with their pre-reform teaching practice tended to be more skeptical of the reformed curriculum. Hence, ignoring teachers' concerns and efficacy beliefs about their pre-reform teaching may hinder successful implementation.

We also found a *a posteriori* analysis from Australia on teachers' implementing a curriculum prescribing thematic teaching (Handal & Bobis, 2004). Interviews with ten teachers in grades 9-10 showed that while the teachers generally appreciated the goals of teaching thematically, they continued to teach procedures topic by topic. According to the teachers, a lack of instructional, curricular, and organizational support hindered the implementation. Also, from Australia, we have an *a posteriori* study identifying high staff turnover and cultural norms as key factors of influence for implementation failure in an analysis of a transfer of curriculum reform from California to remote areas in Aboriginal communities in Australia (Sullivan et al., 2013).

So far, we have not reported on any success stories. However, when we turned to the US, we found only one in our sample. A brief report based on a doctoral dissertation shows positive results on student achievement after implementing two innovations, block-scheduling and standards-based curriculum (Kramer & Keller, 2008). The investigated high school thoroughly prepared the year before the reform. Teachers with a special interest in reformed mathematics were hired, comprehensive professional development for enactment in classroom practice was provided, and organizational support for collaboration between colleagues.

In the other five studies from the US, successful enactment is conspicuous by its absence. A study on twelve first-year teachers in grades 8-10 showed that traditional chalk and talk dominated even though the curriculum prescribed reformed teaching with student participation and problem-solving. (LaBerge & Sons, 1999). The teachers had attended teacher education that did not apply standard-based methods. Self-reported factors of influence revealed by a-posteriori methods were lack of time, resources, and support for changing practice. A lack of support for reform was also identified by Stickles (2011). Electronic logs from 50 elementary school teachers were collected. The results showed that teachers roughly fall into three a posteriori caricatures: the conflicted traditionalists, the growing reformists, and the distinguished leaders. The former has trouble adjusting to reform, while the latter takes on the task in an exemplary manner. The vast majority fall in between (80%). These are teachers with the potential to adapt to reform with proper support. Similar factors of influence, the lack of support for changing practice, are revealed through a posteriori analysis by Swars and Chesnutt (2016). Despite a belief in the merit of the standards, lack of familiarity, inadequate content knowledge, limited curricular resources, and a perceived mismatch with English language learners hindered implementation, according to 73 elementary teachers in a large urban high school (Swars & Chestnutt, 2016). Finally, from the US, a summary paper on the enactment of reformed mathematics in K-12 concludes that the challenges with curriculum reform included both the teachers' views of mathematics as a school subject and their existing images of teaching. For successful reform, teachers' existing views of teaching and their teaching images associated with the reform must change (Taylor, 2002).

Teachers' beliefs were identified as the most important factor of influence for the lack of successful implementation of the reformed curriculum in the last two studies. From China, we have an a-posteriori analyzed single case study of a preschool teacher. The teacher had difficulties implementing the curriculum reform due to a conflict between Standards, the curriculum, and her philosophy and teaching style (Hu et al., 2014). Finally, in Bhutan, a lack of success due to a misalignment between the intentions in the reformed curriculum and teachers' views of classroom practice is reported from an a posteriori analyzed study of 72 elementary teachers (Dolma et al., 2018).

We summarize the results by distributing the factors of influence on the four spheres: the innovation, the user, the organization, and the external environment.

The innovation: The innovation needs to be adapted to the context in which it should be implemented. When transferring an innovation to other cultures than the one the innovation was created for, adaptations are necessary (D'Ambrosio, 1991; Sullivan et al., 2013).

The user: Our sample consists of two a priori studies, where teachers' concerns and efficacy beliefs towards reform are investigated (Charalambous & Philippou, 2010; Christou et al., 2004). Nine other a posteriori studies report results supporting that curriculum change does not occur independently of a change in teachers' concerns, beliefs, views, and images about the nature of mathematics learning and teaching (D'Ambrosio, 1991; Dolma et al., 2018; Handal & Bobis, 2004; Hu et al., 2014; LaBerge & Sons, 1999; Stickles, 2011; Sullivan et al., 2013; Swars & Chestnutt, 2016; Taylor, 2002). It should be noted that affective traits such as concerns, beliefs, views, and images are often not very well defined in individual studies.

The organization: Even if the teachers believe in the reformed ideas, this is not enough for successful reform (Christou et al., 2004; Handal & Bobis, 2004; LaBerge & Sons, 1999; Stickles, 2011; Swars & Chestnutt, 2016). Implementation fails without support structures from the school, providing the teachers with opportunities to understand the intentions of the innovation. Teachers need time and support for planning instruction before launching the reform, as well as support during the implementation. The school also needs to supply sufficient curricular resources that align with the ideas in the reformed curriculum.

The external environment: In the case of implementation, expectations on newly educated teachers and the level of alignment between methods taught in teacher education and required methods in the curriculum that teachers shall teach are influential factors (LaBerge & Sons, 1999).

Discussion

We posed the question: *What factors of influence are decisive for the outcome of the implementation of a curriculum reform?* Our main finding is that changes in accordance with a curriculum innovation do not occur independently of a change in the teachers' concerns, beliefs, views, and images about the nature of mathematics learning and teaching. Most papers highlight affective constructs, such as beliefs and views, as the main factors of influence for the outcome of implementation projects, which may be problematic when analyzing the results of the studies. Not only are affective constructs used and defined differently in the various studies, but this built-in discrepancy also makes it difficult to build on the results in future studies on curriculum adaptations. According to the studies we reviewed, it is not enough that teachers' beliefs are in line with the ideas carried by the innovation. Teachers' curriculum adaptations must be supported by the school organization. The role of the schools' organization is reinforced by the result that even when a majority of the teachers say they are positive towards reform, the change in teachers' beliefs that is supposedly required for a change in teaching practice does not take place, at least not without extensive organizational support. Looking at the matter from the characteristics of the innovation, we see the other side of the same coin. Unless the innovation is adapted, or at least adaptable, to the cultural context and presumably to the system of beliefs and manifested practices of the context of implementation, change is unlikely to occur. Finally, we conclude that the external environment is rarely discussed in our sample.

The main result presented above is in line with a wealth of previous research on curriculum reform and associated teacher change, for example, represented in the theoretical account of the phenomena by Gregoire (2003), the Cognitive–Affective Model of Conceptual Change. According to this model, when teachers' practices are implicated by a reform message, change is likely to occur only when the

reform message is seen as a challenge rather than a threat. Seeing it as a challenge depends on appraising one's own cognitive and affective resources as well as the organizational support as sufficient for enacting a practice in line with the reform message. The only example of effective implementation in our sample reinforces this conclusion. In the case reported by Kramer and Keller (2008), teachers who already believed in the reform ideas were hired and given extensive support in the form of professional development, forums for collaboration, and support in practice. Unfortunately, not all schools can hire teachers who already have the capacity to implement reforms simply because they do not exist. Hence, the approach taken in the project reported by Kramer and Keller appears unrealistic for implementation at a large scale.

Our study is small in scope, which should be kept in mind when reading the results. However, given that our results on the importance of belief alignment and organizational support are indeed in line with previous research, it is surprising to observe so few studies with an a priori approach specifically designed to shed light on the mechanisms of belief change and organizational support. A well-established call from external sources (Chen, 1990) and internal (Century & Cassata, 2016) to educational research is to design for evaluation, explicate the supposed main factors of influence along their mechanisms, and design ways of evaluating these mechanisms. It seems to us that these calls should be taken rather seriously by designers and researchers in the area of curricular reform in order for the field to take further steps toward ensuring effective implementations.

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